OIL AND GAS DRILLING WASTES:

THE POTENTIAL FOR LAND FARMING

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ABSTRACT

Oil and gas drilling operations produce waste materials that are often toxic. High salt concentrations present the main toxicity concern. Salt components such as sodium, potassium and accompanying chloride are the specific cations and anion often found in excess. High pH, frequent oil contamination and many drilling mud additives compound the waste toxicity. These drilling waste components are toxic to plants and animals and can also adversely affect soils at high concentrations. If the salts can be reduced to an acceptable level, however, the wastes can then be spread onto the soil surface. The drilling waste texture would improve sandy soil texture when the two are mixed. Any toxic organic components can be ameliorated by soil microbial activity and surface aeration. Land farming drilling wastes can help eliminate a toxic waste problem and potentially improve an unproductive sandy soil.

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Oil and gas drilling waste disposal is an integral component of all drilling activity in Alberta. Because the wastes are often toxic in nature (they are lethal to trout fingerlings), the material has the potential to adversely affect the forested, agricultural and range lands in Alberta. In 1983-84, 10 924 wells were spudded. Sump fluids were tested for 574 of these wells and 344, or 60%, were found to be toxic (ERCB 1985). Surface land application of drilling wastes, including both the fluid and the solid components, is one possible method to effectively manage waste toxicity.

DRILLING WASTE COMPONENTS

a) General Characteristics

Figure 1 indicates the general components of drilling wastes. A major portion of the waste is cuttings that come up from the bore hole and the water used to lubricate the bit and carry the cuttings. The various additives used to produce the fluid drilling characteristics needed and the substances that inadvertently find their way into a waste pit are minor components of a waste system. The physical and chemical characteristics of drilling waste must be understood in order to determine the best disposal of the waste material.

b) Waste Analysis

Drilling wastes are often found in layers within any storage pit. Chemical complexity, season of deposition (e.g., winter storage in a pit can

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FIGURE 1

DRILLING WASTE COMPONENTS

A) COMPONENTS OF WATER BASED MUDS

- Water
- Bentonite (Gel) Viscosified
  - sodium montmorillonite 35-70 kg/m^3
  - caustic soda (NaOH) at pH of 9-10
  - carboxymethylcellulose 1-3 kg/m^3
  - polyacrylamides (viscosity extender)
- KCl - 20000 - 40000 mg L^{-1}
- K_2SO_4 - 10000 - 30000 mg L^{-1}
- NaCL - up to 200000 mg L^{-1}
- cuttings from the hold being drilled

B) TREATMENT ADDITIVES - 16 CATEGORIES

Some are:
1) Alkalinity pH control - $NaHCO_3$
2) Corrosion Inhibitors - Ammonium bisulfate (oxygen scavenger)
3) Thinners - Calcium lignosulfonate
4) Weighting Materials - Barite
5) Lubricants - graphite, oil
6) Lost Circulation - NaCL, sawdust, walnut hulls

C) OTHER COMPONENTS

- spent crank case oil
- plastic sheeting
- used cans, plastic bottles, glass bottles
- rig wash
- garbage debris
- gasoline, diesel fuel

promote layering because of layer freezing and because of the thixotropic nature of the mud) and settling can all influence the degree of layering that may occur in a waste pit. Four or more layer sequences may be evident in a waste pit. There is often a surface oily scum, followed by a water layer, then a water solid phase and a more solid phase. The solid phase may still be 70% water and the semi-solid phase 10-15% solids. Past sump sampling has indicated that different concentrations of salts can be found throughout the sump pit, both laterally and horizontally (Specken 1975). Any sump sampling for chemical analysis should, therefore, include water, semi-solid and solid samples to account for waste pit chemical variability.

An analysis of drilling wastes was conducted by a commercial lab for solids and the Energy Resources Conservation Board for liquids. Table 1 represents the solids and liquid analysis for three different mud systems. The salts present the main problem. At the high concentrations indicated in the sodium mud, the salts would have to be washed out of the muds before any kind of disposal could occur. Adverse soil impact would only be mitigated if the sodium were leached out and a more appropriate calcium/magnesium balance established. A calcium leaching amendment (gypsum for the freshwater system and lime for the sodium chloride system) should be used for salt systems; they are to be surface soil incorporated. The KCl system in this case shows reasonable chemical levels except that the pH would have to be adjusted, as it would for the freshwater system. The samples of these systems were quick grab samples from one location in the sump. Actual sump chemical makeup, therefore, may vary from that shown in Table 1.

Table 2 illustrates an example of trace elements or heavy metals analysed for each of the three mud systems. If one assumes a soil bulk density of about 1.4 g/cc then the actual weight per area (kg/ha) application per 15 cm soil depth would be approximately twice the figures shown in Table 3. Given that the analysis is from a complete acid digest of the waste sample, the numbers shown in Table 3 are much higher than the amount of metal or element that would actually be available to the environment if the material were surface soil-applied and incorporated 15 cm deep. These three mud systems do not indicate a heavy metal problem if the actual sample were representative of the pits sampled.

Table 1

Analytical Results of a KCl Sump, a Fresh Water Gel Sump and a NaCl Sump.

Location	Cl Sump Type*	Cl mg/l	SO4 mg/l	HCO3 mg/l	CO3 mg/l	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	SAR mg/l	EC mS/cm	Sat%	pH	ESP	Gypsum T/ha
NW Plains	KCl-Polymer - Solids	925	2,152	87.8	30	851	41.4	838	5.8	8	5.9	64	10.4	14.6	2.2
	- Liquids	690	616	219	72	690	24	180					9.0		
NE Plains	Fresh Water Gel - Solids	103	999	176	96	858	10.6	54.3	0.5	32	4.2	110	11.5	43.7	15.7
	- Liquids	135	111	128	144	270	3	162					10.0		
NE Plains	NaCl - Solids	67,361	5,523	146	30	43,681	133	1,494	4.1	311	117	63	10.3	88.1	233
	- Liquids	80,092	2,057		467	55,000	179	221					11.9		

Location	Sump Type*	Oil %	Carbon %	Available N kg/ha	Available P kg/ha	Available K kg/ha	Sand %	Silt %	Clay %	Texture	CEC
NW Plains	KCl-Polyer - Solids	0.12	1.0	2	1	488	32	44	24	L	24.4
NE Plains	Fresh Water Gel - Solids	0.22	1.3	6	1	456	36	32	32	CL	20.6
NE Plains	NaCl - Solids	0.36	2.5	8	1	585	42	34	24	L	32.4

* Solids analyzed by a commercial laboratory.
Liquids analyzed by the ERCB Laboratory.

Table 2

OIL AND GAS DRILLING WASTES
TRACE ELEMENTS*

(I.C.P. Scan of Acid Digests)
(Units in ugg^{-1})

	KCl Mud	NaCl Mud	Freshwater Mud
Boron (B)	33.80	40.60	26.30
Cadmium (Cd)	0.01	0.01	0.01
Copper (Cu)	21.90	15.10	16.30
Chromium (Cr)	27.40	107.00	9.53
Lead (Pb)	29.80	44.20	26.00
Nickel (Ni)	25.00	19.40	22.70
Zinc (Zn)	69.30	96.00	60.60

* Analysis done by commercial laboratory.

THE POTENTIAL FOR LAND FARMING

Land application and surface incorporation or land farming of oil and gas drilling wastes is a safe and controlled approach to drilling waste disposal. Standard waste sampling and disposal problems support land farming of oil and gas drilling wastes.

a) Waste Analysis Problems

Accurate analysis for reliable waste toxicity is not easily obtained. The trout check for toxicity remains the most consistent and sure analysis for toxicity. Monovalent cations such as sodium and potassium are lethal to trout in higher concentrations if wastes are unbuffered by divalent cations such as calcium. Trout are not, however, the only organisms adversely affected by wastes. Soils, vegetation and soil microbial populations must also be considered. Because of the complexity and number of different chemicals in drilling wastes, actual adverse effects on soils, vegetation and trout and the specific reasons for the effects are difficult to determine.

b) Waste Sampling Problems

Sampling wastes presents a unique problem. Because sumps may be layered both vertically and horizontally, and because there are the different solid and liquid fractions, a representative sump sample is difficult to obtain. Sampling to date has been primarily from sump surfaces. To what degree the settled solids in a sump harbor greater concentrations of drilling fluid additives and refuse toxic constituents is not really known.

c) Standard Waste Disposal Problems

Standard sump disposal such as burial, squeezing and modified trenching tends to leave a large portion of waste buried in the sump pit. It may be that the more contaminated portion of the sump is the portion that is left buried and untreated.

To ensure safe waste disposal, land farming reasonably guarantees that all the waste material is properly handled. Wastes spread over a larger surface area are sufficiently diluted. Lightweight oil fractions are likely

to be volatilized and heavier weight oil fractions are likely to be biologically degraded in the active soil microbial layer. Surface spreading mitigates the uncertainty of proper sump sampling and helps compensate for the lack of accuracy in waste toxicity analysis. Land farming ensures that if a toxic problem arises the problem material is immediately accessible for remedial action.

Other benefits are possible if land farming is practised. Land farming allows for easier chemical amendment. Surface spreading and incorporation have potential for beneficial waste use such as waste application to very sandy soils. The drilling waste would improve sandy soil texture and water holding capacity. Land application or farming of oil and gas drilling wastes thus ensures that all the waste material is properly disposed of and handled.

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